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Preparatory Joint Working Group on Neo-Deterministic Seismic Hazard Assessment (pJWG NDSHA)

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More reliable physics in seismic hazard assessment (SHA) for disaster risk reduction (DRR)

(More reliable physics in SHA for DRR)

This issue

Real time falsification and reality check of Panza-Rugarli (PR) Law

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Real time falsification and reality check of Panza-Rugarli (PR) Law

(1) A brief comment on the recent major earthquakes in NW of Caribbean plate boundary (From: Vladimir Kossobokov)

The recent **M 7.6 - 209 km SSW of George Town, Cayman Islands** {2025-02-08 23:23:14 (UTC) 17.702°N 82.456°W 10.0 km depth} (yellow dot in the Figure 1 below) is another failure of the 1999 GSHAP Global Final Map[1,2] where *PGA 10% poe in 50 years* at the underwater grid point (17.7°N, 82.5°W) is 2.13392 ms^{-2} (note no values offshore in the most recent GEM's Global SEISMIC HAZARD MAP version 2019.1[3,4]). According to USGS solution PGA was 50% g over 70 km fault slip. Thus, we have another case of a factor 2.3 underestimation by the widespread Probabilistic Seismic Hazard Analysis (PSHA) that corresponds to the unacceptable difference of 2 MMI units at epicenter.

The maximum magnitude at 100 km distance from the epicenter reported since 1900 is 6.3, due to **M 6.3 - 209 km SSW of George Town, Cayman Islands** {1999-12-01 19:23:06 (UTC) 17.647°N 82.356°W 10.0 km depth} almost at the same point. So that $M_{design} = M_{max} + \gamma_{EM}\sigma_M$ value, with a safety factor γ_{EM} = 1.5-2.5 and the typical, at global scale, error in magnitude determination σ_M = 0.2-0.3 per Rugarli et al. (2019), underestimates seismic potential in advance of the February 8th, 2025 major earthquake. However, when a larger distance is considered, we find the epicenter of **M 7.5 - 203 km NNE of Barra Patuca, Honduras** {2018-01-10 02:51:33 (UTC) 17.483°N 83.520°W 19.0 km depth} earthquake (cyan dot in the figure below) at 115 km from the February 8th epicenter suggesting **an option of using scalable radius R, e.g. proportional to the length of incipient earthquake rupture L in the M_{design} estimation**.

The January 10th, 2018, M 7.5 earthquake is an earlier failure of the 1999 GSHAP Global Final Map with a factor 2.8 underestimation of PGA; compare 1.73572 ms^{-2} of *PGA 10% poe in 50 years* at (17.5°N, 83.5°W) to 50% g along rather compact fault slip ~40 km, according to the U.S. Geological Survey's finite fault model.

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[1] https://www.gfz.de/en/gshap.

[2] http://gmo.gfz-potsdam.de/pub/download_data/download_data_frame.html.

[3] https://doi.org/10.13117/GEM-GLOBAL-SEISMIC-HAZARD-MAP-2018.1.

[4] https://maps.openquake.org/map/global-seismic-hazard-map/.

Note also the GSHAP apparent underestimation of seismic hazard by 2 MMI units along the entire transition zone in NW of Caribbean plate.

For the 2018, M 7.5 major earthquake there is the epicenter of **M 6.8 - 140 km N of Barra Patuca, Honduras** {1910-01-01 11:01:58 (UTC)17.068°N 84.191°W15.0 km depth} strong earthquake at 85 km distance, which makes negligible its difference with M_{design} per Rugarli et al. (2019) described above.

Thus, the case-history confirms once again (Kosobokov & Nekrasova 2012; Wyss et al. 2012; Rugarli et al. 2019; Panza et al. 2021; Kossobokov & Panza 2022; Wen & Wang 2024):

(i) the *usefulness* of seismic hazard assessment and mapping based on M_{max} observations (e.g., by a simple straightforward calculations of M_{design}), and

(ii) the *harmfulness* of Probabilistic Seismic Hazard Analysis (PSHA), which is *inadmissible for any type of responsible evaluation of seismic risk and decision-making aimed at earthquake mitigation and/or prevention*.

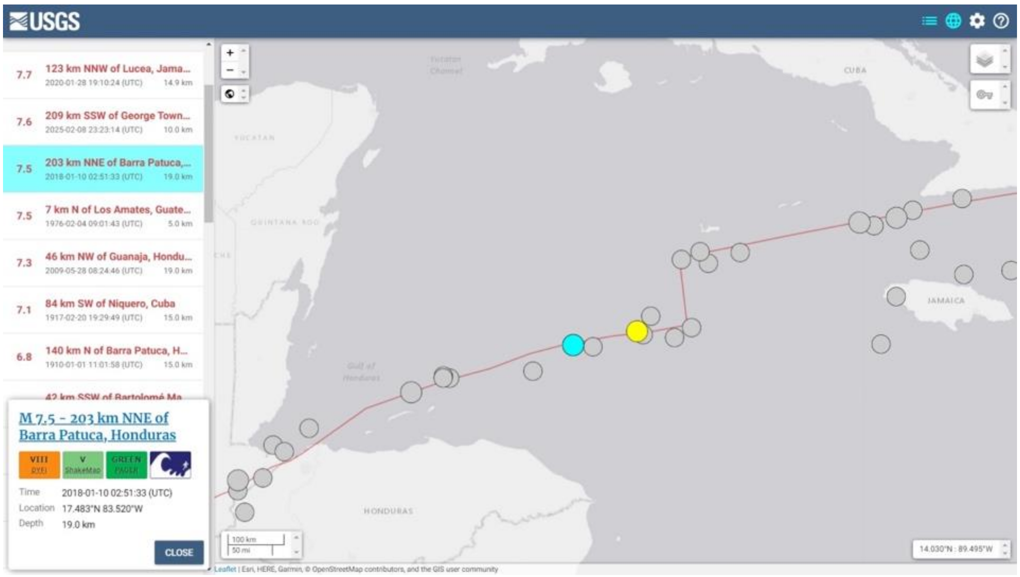

Figure 1. The magnitude M ⩾ 6.0 earthquakes since 1900 in NW of Caribbean plate (ANSS Comprehensive Catalog on-line search[5]).

References:

Kossobokov, V. G., Nekrasova, A. K., 2012. Global Seismic Hazard Assessment Program Maps are Erroneous. *Seismic Instruments*, 48: 162-170.

Kossobokov, V., Panza, G., 2022. Seismic Roulette: Hazards and Risks. *Terra Nova*, 34: 475-494.

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Rugarli, P., Vaccari, F., Panza, G.F., 2019. Seismogenic nodes as a viable alternative to seismogenic zones and observed seismicity for the definition of seismic hazard at regional scale. *Vietnam Journal of Earth Sciences*, 41, 289–304.

[5] https://earthquake.usgs.gov/earthquakes/search/.

Wen, Z. P., Wang, G. X., 2024. Earthquakes and Sustainable Infrastructure - Neodeterministic (NDSHA) Approach Guarantees Prevention Rather Than Cure. *Earthquake Science*, 37, 494-497.

Wyss, M., Nekrasova, A., Kossobokov, V., 2012. Errors in expected human losses due to incorrect seismic hazard estimates. *Natural Hazards*, 62: 927-935

(2) M_{design} estimation for the area affected by the cluster with M<5.6 started with mb 5.0 quake in Dodecanese Islands, Greece, on, 17th February, 2025 (From: Yan Zhang and Giuliano Panza)

Reported by the United States Geological Survey (USGS), a cluster with, so far, M<5.6 started with mb 5.0 quake in Dodecanese Islands, Greece, on 17th February 2025. The parametric catalogue is shown in Table 1; it starts in 1908. Figure 2 shows the spatial distribution of historical earthquakes around the cluster area. One can find the *M*5.7 1956-07-10 event, 36 km away from *M*5.1 2025-02-18 event. According to Panza-Rugarli (PR) Law (Wang and Wen, 2024), M_{design} can be defined as follows:

$$M_{design}=5.7+0.7=6.4$$

According to the University of Athens (EKPA) seismology laboratory[6], more than 18,400 *M*3.0~5.2 quakes were recorded off the islands in the Cyclades archipelago during January 26th ~ February 13th. The cluster did not exceed the M_{design}. Noticed that the value of M_{design} 6.4 has been exceeded by the *M*7.7 1956-07-09 event, and since the difference 1.3 is much larger than 1/4, M_{design} should be defined now as at least 7.7, better 8.4. Please note that the distance of this cluster to the Minoan eruption that devastated the Aegean island of Thera circa 1600 BCE[7] is around 30 km, to the 365 Crete earthquake occurred on 21 July 365 in the Eastern Mediterranean[8] is around 300 km.

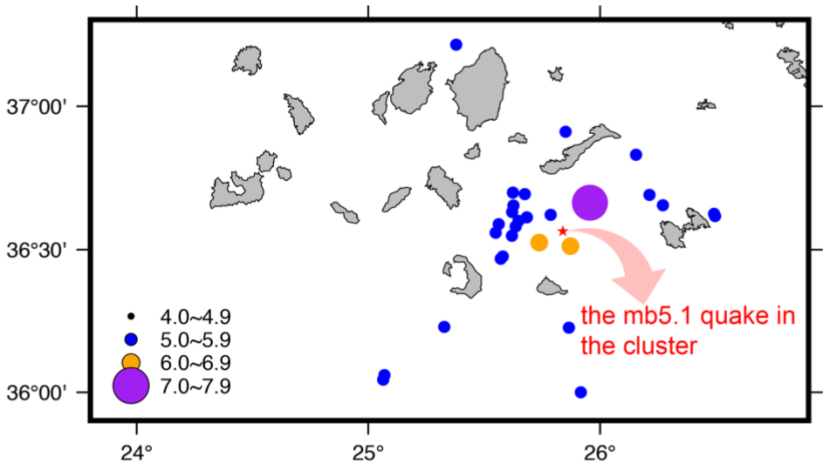

Figure 2 Spatial distribution of epicenters of historical events occurred in the area of the ongoing cluster in Dodecanese Islands, Greece, in 2025 (see Table 1) grouped in one unit of magnitude.

Reference:

[6] https://www.aa.com.tr/en/europe/greece-51-magnitude-earthquake-strikes-between-amorgos-santorini/3484498#

[7] https://en.wikipedia.org/wiki/Minoan_eruption.

[8] https://en.wikipedia.org/wiki/365_Crete_earthquake.

Wen, Z. P., Wang, G. X., 2024. Earthquakes and Sustainable Infrastructure - Neodeterministic (NDSHA) Approach Guarantees Prevention Rather Than Cure. Earthquake Science, 37, 494-497.

Table 1. M≥5.0 earthquake catalogue, since 1908, within 100km distance from the mb 5.1 quake, shown as star, in the cluster.

Time	Latitude(°)	longitude(°)	Depth(km)	Mag	Distance(km)
2025-02-18T04:46:52.332Z	36.5641	25.8397	10	5.1	0.0
2025-02-17T07:49:49.992Z	36.6009	25.6487	10	5.0	17.5
2025-02-12T08:29:51.305Z	36.5888	25.5632	10	5.0	24.8
2025-02-12T01:14:54.177Z	36.5596	25.5495	10	5.1	25.9
2025-02-10T22:37:24.695Z	36.6318	25.6213	10	5.1	20.9
2025-02-10T20:16:28.890Z	36.6944	25.6758	10	5.2	20.6
2025-02-09T19:05:38.592Z	36.6992	25.6236	10	5.2	24.4
2025-02-08T09:00:40.940Z	36.4687	25.5717	10	5.1	26.2
2025-02-07T07:16:15.076Z	36.5485	25.6196	10	5.1	19.7
2025-02-05T19:09:38.761Z	36.6542	25.6259	10	5.1	21.6
2025-02-04T13:04:14.289Z	36.4761	25.5809	13	5.3	25.1
2025-02-04T02:46:06.292Z	36.5816	25.636	10	5.1	18.3
2025-02-03T09:29:43.438Z	36.6133	25.6841	10	5.0	14.9
2012-01-27T01:33:24.000Z	36.044	25.064	5	5.3	90.4
2012-01-26T04:24:58.300Z	36.06	25.07	29	5.2	88.9
2007-08-31T20:52:43.430Z	36.655	26.272	25	5.2	39.9
1959-05-20T16:36:54.510Z	36.625	26.493	15	5.2	58.7
1956-07-30T10:40:00.610Z	36.00	25.917	15	5.7	63.1
1956-07-22T03:29:00.280Z	36.617	26.497	15	5.4	59.0
1956-07-10T03:01:29.240Z	36.691	26.214	15	5.7	36.3
1956-07-09T21:28:42.850Z	36.227	25.866	15	5.3	37.6
1956-07-09T20:13:57.290Z	36.831	26.156	15	5.5	40.9
1956-07-09T06:22:49.990Z	36.622	25.787	15	5.5	8.0
1956-07-09T03:11:45.150Z	36.664	25.957	20	7.7	15.3
1934-11-09T13:40:47.690Z	36.229	25.328	15	5.6	59.0
1932-04-23T09:57:47.050Z	37.214	25.379	15	5.3	83.1
1919-10-25T17:10:07.230Z	36.512	25.872	15	6.0	6.5
1911-04-04T15:43:48.980Z	36.525	25.738	15	6.1	10.1
1908-06-23T16:01:59.040Z	36.911	25.852	15	5.5	38.6

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